Colorado Front Range Seismicity and Seismic Hazard
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Non-technical Summary:

This project has included the archiving of earthquake seismic data from a temporary seismic experiment in Colorado from 1992. The experiment consisted of thirty broadband seismograph stations deployed throughout the state of Colorado. These stations continuously recorded data, but the local earthquakes had not been examined. These data were archived and are now being used to study earthquakes in Colorado and the surrounding area. Over 100 seismic events have been identified to date. Ongoing work includes locating the earthquakes, distinguishing earthquakes from mining blasts, determining the magnitude of the earthquakes, and determining the faulting geometry associated with the earthquakes.

Investigations undertaken:

This project involves the study of seismicity in the state of Colorado and surrounding areas using data from the 1992 IRIS Passcal Rocky Mountain Front (RMF) experiment. The RMF experiment involved the deployment of 30 broadband seismic stations throughout Colorado and into Kansas and Utah for six months in 1992. The stations recorded in both continuous and triggered modes. The experiment was run before IRIS required submission of continuous data in SEED format to the IRIS DMC, so all that had been submitted to IRIS were parsed events (mostly teleseisms). Thus a large part of the data set had not been archived, and no work had been done on local seismicity using this data set. The archiving of this data set makes our own proposed work possible, as well as making the data available to others. A large part of this year's effort involved acquiring all of the original RMF field tapes from Lamont, reading them on to computer disk, and formatting them into SEED format for submission to the IRIS Data Management Center. Converting the data from 32 Gb of raw field dumps to 20 Gb of archival SEED format data was a major task. Dealing with timing corrections proved to be particularly challenging, as the data were collected using a mix of timing systems, each with their own quirks. For example, the radio wave Omega timing system (which no longer exists) had a leap second in the middle of the experiment that needed to be corrected for, and had cycle skips (10 s period) related to the period of the Omega wave signal. GPS clocks at that time were fairly new, and had some issues with 1 s timing jumps and wanting to locate the experiment in Dallas (the home of Reftek).

The Rocky Mountain Front data were imported into an Antelope database for formatting and preparation of SEED volumes, data management , and analysis. The

standard steps of using Antelope codes refrate and clockcor to apply the timing corrections could not be applied in the standard manner due to the variety and age of timing systems used in the RMF experiment. The Passcal time correction files had to be recreated for each Reftek DAS, and each of these had to be checked visually for problematic areas (for example, a bad battery will have large nearly sinusoidal corrections with a period of a day). There was a '1988' bug (about 5-10% of the files had 1988 as the date, a common bug) that had to be corrected, and the leap second correction had to be applied to DAS's that used omega timing, but not to those with a GPS clock. This was done for all 10 sps continuous data and the triggered 20 sps data. Many checks were performed to verify the timing.

The Antelope code dbsteimu was used to create the wfdisc (waveform database). The script mkfull_db.csh was used to create parameter files RMF_Dbcorr, affiliation, calibration, instrument, lastid, sensor, network, site, sitechan, and stage files. The code dbfixchanids was run to make sure that the Reftek DAS's were mapped to the right stations. After this, dbverify was run to check the database. Some minor reformatting was needed.

Data were run through autodetection and autodetection parameters were tested (parameters used, how many detections, false alarm rate). Autodetection was performed using dbdetect. Short term average/long term average (STA/LTA) parameters were tested for regional type settings. An rms process was used rather than a filter, and the signal to noise minimum was 2.5. The programs ttgrid, dbtrigger, and dbgrassoc were used in event association. For dbgrassoc a grid search is used to search for event location given the event triggers. We set the minimum number of stations to 3. The false alarm rate was high, but missed nearly nothing. As a check, Ivan Wong's Front Range network catalog and the USBR Paradox catalog were examined for the time period coincident with the RMF experiment. There were only two slightly distinguishable (probably not pickable) events that were in the Wong or USBR catalogs that were missed by the RMF autodetect.

To date, 70% of the RMF data have been picked. Approximately 200 events have been identified, but many are outside of the network. We anticipate that we will locate approximately 100 events within our network. Local magnitudes will be determined for all events located. Polarities will be picked for the best events, and focal mechanisms determined.

Results:

Results include writing 20 Gb of broadband seismic data from a six-month temporary seismic deployment to archival SEED format, for submission to the IRIS Data Management Center. The data have been organized into an Antelope database. Approximately 70% of the seismic data have been picked, and over 100 events located.

Reports published/Professional presentations:

Bensen, G., C. Meertens, and A. Sheehan, Information technology developments for geophysical data, *Geol. Soc. Am. Annual Meeting*, Denver, November 2004.

Bensen, G., C. Meertens, and A. Sheehan, Information technology developments for geodynamics, American Geophysical Union, Fall Meeting 2004.

Bensen, G., C. Meertens, and A. Sheehan, Colorado seismicity, data visualization and IT research at UNAVCO, *Rocky Mountain Earthscope Workshop I, Sevilleta National Wildlife Refuge and Long Term Ecological Research Facility,* Socorro, New Mexico, September 15-17, 2004.

Data products:

20 Gb of broadband seismic waveform data from a 30 station, 6 month temporary deployment of broadband seismometers throughout Colorado. The data are in SEED format. Data are available from Anne Sheehan at the University of Colorado at Boulder, afs@cires.Colorado.edu. All seismic data will be submitted to the IRIS Data Management Center in early Spring 2005.